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Analyses of internal tides generation and propagation over a Gaussian ridge in laboratory and numerical experiments

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Internal tides are suggested to play a major role in the sustaining of the global oceanic circulation [1][5]. Although the exact origin of the energy conversions occurring in stratified fluids is questioned [2], it is clear that the diapycnal energy transfers provided by the energy cascade of internal gravity waves generated at tidal frequencies in regions of steep bathymetry is strongly linked to the general circulation energy balance.
Therefore a precise quantification of the energy supply by internal waves is a crucial step in forecasting climate, since it improves our understanding of the underlying physical processes.
We focus on an academic case of internal waves generated over an oceanic ridge in a linearly stratified fluid. In order to accurately quantify the diapycnal energy transfers caused by internal waves dynamics, we adopt a complementary approach involving both laboratory and numerical experiments.

The laboratory experiments are conducted in a 4m long tank of the CNRM-GAME fluid mechanics laboratory, well known for its large stratified water flume (e.g. Knigge et al [3]). The horizontal oscillation at precisely controlled frequency of a Gaussian ridge immersed in a linearly stratified fluid generates internal gravity waves. The ridge of e-folding width 3.6 cm is 10 cm high and spans 50 cm. We use PIV and Synthetic Schlieren measurement techniques, to retrieve the high resolution velocity and stratification anomaly fields in the 2D vertical plane across the ridge. These experiments allow us to get access to real and exhaustive measurements of a wide range of internal waves regimes by varying the precisely controlled experimental parameters.
To complete this work, we carry out some direct numerical simulations with the same parameters (forcing amplitude and frequency, initial stratification, boundary conditions) as the laboratory experiments. The model used is a non-hydrostatic version of the numerical model Symphonie [4]. Our purpose is not only to test the dynamics and energetics of the numerical model, but also to advance the analysis based on combined wavelet and empirical orthogonal function.

In particular, we focus on the study of the transient regime of internal wave generation near the ridge. Our analyses of the experimental fields show that, for fixed background stratification and topography, the evolution of the stratification anomaly strongly depends on the forcing frequency. The duration of the transient regime, as well as the amplitude reached in the stationary state vary significantly with the parameter ω/N (where ω is the forcing frequency, and N is the background Brunt-Väisälä frequency). We also observe that, for particular forcing frequencies, for which the ridge slope matches the critical slope of the first harmonic mode, internal waves are excited both at the fundamental and the first harmonic frequency. Associated energy transfers are finally evaluated both experimentally and numerically, enabling us to highlight the similarities and discrepancies between the laboratory experiments and the numerical simulations.

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